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Quarterly Progress Report
on the
Utilization of UARS data in Validation of Photochemical and Dynamical
Mechanism in Stratospheric Models
(Contract NAS5-32844)

by
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1. Introduction

The global three-dimensional measurement of long and short-lived species from UARS provides a unique opportunity to validate chemistry and dynamics mechanisms in the middle atmosphere. During the past three months, we focused on expanding our study of data-model comparisons to whole time periods when CLAES instrument were operating (January 9, 1992 to May 5, 1993).

A theory for the existence and significance of species correlations was proposed by Plumb and Ko (1992). In this theory, compact relationships can be expected only between long-lived species whose local lifetime are longer than quasi-horizontal transport time. They argued that the slope of the curve is equal to the ratio of net global vertical fluxes of the two species through the rapid exchange surface. A linear relationship is expected only for very long lived species whose vertical transport time scales are in gradient equilibrium. Some correlation diagrams, such as linear correlations of some stratospheric tracers with N_2O , have been used as a diagnostic procedure to test chemical-transport models. The departures from the correlations also suggest effects from anomalous chemistry, such as denitrification (Fahey et al, 1990).

Correlations of N_2O vs CH_4 and N_2O vs NO_y are studied in the current report. There are two purposes. First, we want to explore the possibility of deriving NO_y from UARS measurements to use in the AER box model to calculate NO_x/NO_y ratios. Secondly, we hope to test AER 2-D model utilizing the observational values from UARS. Data sources and analysis procedures will be discussed in Section 2 and analysis results and discussion will be given in Section 3. Future works will be addressed in Section 4.

2. Data Sources and Methodology

For our analysis, we used UARS level 3AT data to obtain daily HALOE (version 17) and CLAES (Version 7) data. Level 3AT data is organized by time along the orbit tracks. HALOE measures profiles for O_3 , HCl , HF , CH_4 , H_2O , NO , NO_2 and aerosols from about 15km to 60-150km. From CLAES measurement profiles of thirteen species (O_3 , H_2O , CH_4 , N_2O , NO , NO_2 , N_2O_5 , HNO_3 , ClONO_2 , HCl , CFC-11 , CFC-12 and aerosols) have been retrieved between 10km and 60km with a vertical resolution of 2.5km. HALOE and CLAES have different viewing geometries. HALOE provides 30 profiles on two latitude circles daily, one corresponding to sunrise locations, the other corresponding to sunset locations. CLAES views daily from 34 degrees latitude on one side of the equator to 80 degrees in the other with 36-day yaw cycles, viewing the northern and southern high latitudes alternately. In our analysis, we used HALOE's CH_4 , NO and NO_2 , interpolating CLAES data to get N_2O , HNO_3 , ClONO_2 and N_2O_5 values at the closest locations to HALOE's measurements on same day. Because of the different viewing geometry between HALOE and CLAES, on any given day the two latitude circles viewed by HALOE may not necessarily lie within the latitudinal range of CLAES.

To calculate NO_y, we simply added up HALOE's NO, NO₂ and CLAES's HNO₃, ClONO₂ and twice N₂O₅. Since HALOE and CLAES instruments did not make simultaneous measurements, the diurnal variation of NO_x (NO plus NO₂), ClONO₂ and N₂O₅ measured at different local solar time would lead to an error for NO_y. HNO₃ is a diurnally stable species in the lower and middle stratosphere. HNO₃ and NO_x constitute more than 80% of total NO_y in the stratosphere (see Figure 1). The contribution of NO_y from N₂O₅ and ClONO₂ would be under 20% (1-2ppbv). Thus, the error from the diurnal variations of N₂O₅ and ClONO₂ is expected to be within the noise level of NO_y (20 %).

We did our analysis during the CLAES operating period which was from January 1992 to May 1993. The correlations of CH₄ (HALOE) vs N₂O (CLAES) and N₂O vs NO_y (HALOE and CLAES) were analyzed with the altitude range of 100mb to 1mb wherever data were available. The results are given in the next section, with comparisons of ATMOS data (from H. Michelson) and AER 2-D model output.

3. Results and Discussion

The correlations will be shown at 30N-40N, 10N-10S and 30S-40S latitudinal bins in January, April, July and October from January '92 to April'93, compared with the results from ATMOS and AER 2-D model. ATMOS data was obtained from ATLAS (Mar.25-Apr.2, '92), ATLAS2 (Apr. 8-14, '93) and ATLAS3 (Nov. 3-12,'94) using trajectory models as a filter to distinguish air masses (Michelson 1996; personal communication). In the middle latitudes, ATMOS data were generally from middle and high latitudes of northern hemisphere. The outputs of AER 2-D model are from 38N, 38S and equatorial latitudinal bins individually.

The correlations of N₂O vs CH₄ from ATMOS and AER 2-D model are shown in Figure 2. Model results indicate that the seasonal variations latitudes are very small. The data from UARS are given in Figure 3 to 6. ATMOS and AER 2-D model output are also plotted in the same figures for comparison. ATMOS data are plotted in red lines. The output from AER 2-D model is plotted as blue lines. UARS data are indicated by plus sign. The green lines are polynomial fitting curves based on UARS data. Below 50ppbv of N₂O, CH₄-N₂O points are fitted as cubic curves. Above 50ppbv of N₂O, a linear fitting is applied. Generally, there is fairly good agreement between UARS, ATMOS data and AER 2-D models. The variations between the three curves are about 10-20%. UARS data points are more scattered than those from ATMOS and aircraft measurement (Michelson 1996; NASA Reference Publication 1292, Vol. III, 1993), which could be due to the larger error bars of UARS data.

Figure 7 show the seasonal variations of correlations of N₂O vs NO_y in the equator, and northern and southern middle latitudes. Above 100ppbv of N₂O, the negative linear correlations between N₂O and CH₄ are generally in good agreement between ATMOS and model outputs. UARS data are plotted in Figure 8 to 11. The color coding of Figures 8-11 is the same as Figure 3. The red, blue and green lines are identified the data from ATMOS, AER 2-D model and UARS measurements. Below 100ppbv of N₂O, the N₂O-NO_y points of UARS are fitted as cubic curve. Above 100ppbv of N₂O, N₂O vs NO_y points are fitted in a linear line. The negative linear correlations of N₂O vs NO_y (when N₂O is greater than

100ppbv) are in a better agreement between observations and models. When N_2O is less than 100ppbv, the turning points of N_2O - NO_y from positive to negative correlation (around 50ppbv of N_2O) varies with latitudes from season to season. In the summer hemisphere, there are better agreements (30S-40S, Jan. '92 and 30N-40N, Jul. '92) between UARS, ATMOS and AER 2-D models than those in the winter hemisphere (30N-40N, Jan. '92 and 30S-40S Jul. '92). Since the planetary waves are more active in the winter hemisphere, air mass of middle latitude could be contaminated by polar air, which could cause such discrepancies. In the tropics, the discrepancies are getting larger, especially when N_2O is less than 100ppbv. This could be associated with the interference of Mount Pinatubo sulfate aerosol layer (Roche et al 1996).

4. Future Works

NO_y derived from HALOE and CLAES as well as the ones derived from correlations will be used in our photochemistry box model to study NO_x/NO_y ratios

Continue testing 2-D model with UARS data. In particular, we will explore whether the disagreements are due to contamination with air from tropical (polar) regions.

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- Roche, A. E., et al, "Validation of CH_4 and N_2O measurements by the cryogenic limb array etalon spectrometer instrument on the Upper Atmosphere Research Satellite", JGR, 101, 9679-9710, 1996.

Figure List

Figure 1: The percentage contributions to NO_y from NO_x (NO+NO₂), HNO₃, ClONO₂ and N₂O₅ from UARS HALOE and CLAES measurement in July, 1992 between 30N-40N.

Figure 2: N₂O vs CH₄ correlations from ATMOS and AER 2-D model in January, April, July and October at 47N (a), equator (b), and 47S (c).

Figure 3: N₂O vs CH₄ correlations from UARS measurements in January, at 38N (a) equator (b), and 38S (c) in comparison with ATMOS and AER 2-D model output.

Figure 4: Same as Figure 3 but for April.

Figure 5: Same as Figure 3 but for July.

Figure 6: Same as Figure 3 but for October.

Figure 7: N₂O vs NO_y correlations from ATMOS and AER 2-D model in January, April, July and October at 47N (a), equator (b), and 47S (c).

Figure 8: N₂O vs NO_y correlations from UARS measurements in January, at 38N (a) equator (b), and 38S (c) in comparison with ATMOS and AER 2-D model output.

Figure 9: Same as Figure 8, but for April.

Figure 10: Same as Figure 8, but for July.

Figure 11. Same as Figure 8, but for October.

Percentage Contribution to NO_y (HALOE, CLAES data in July 92 30N–40N)

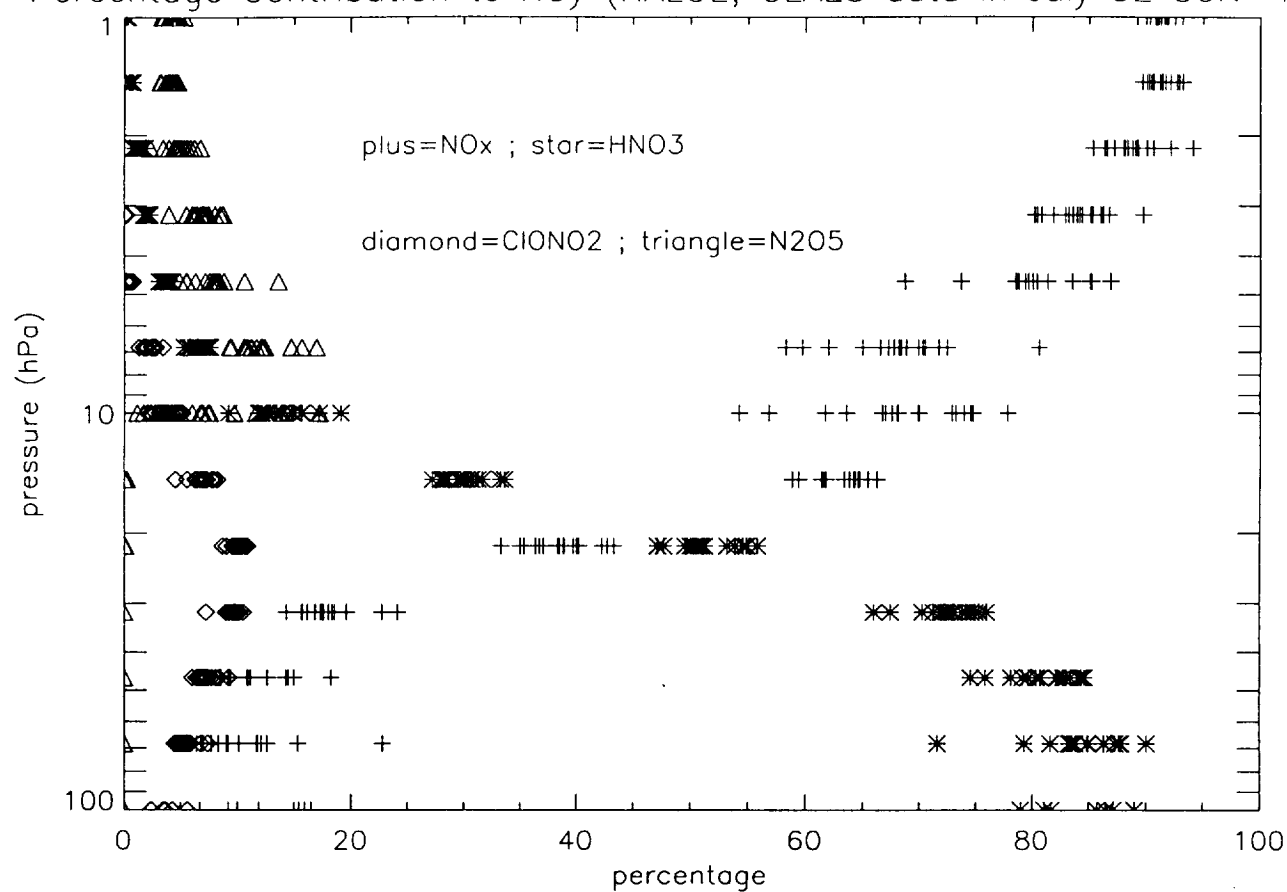


Figure 1

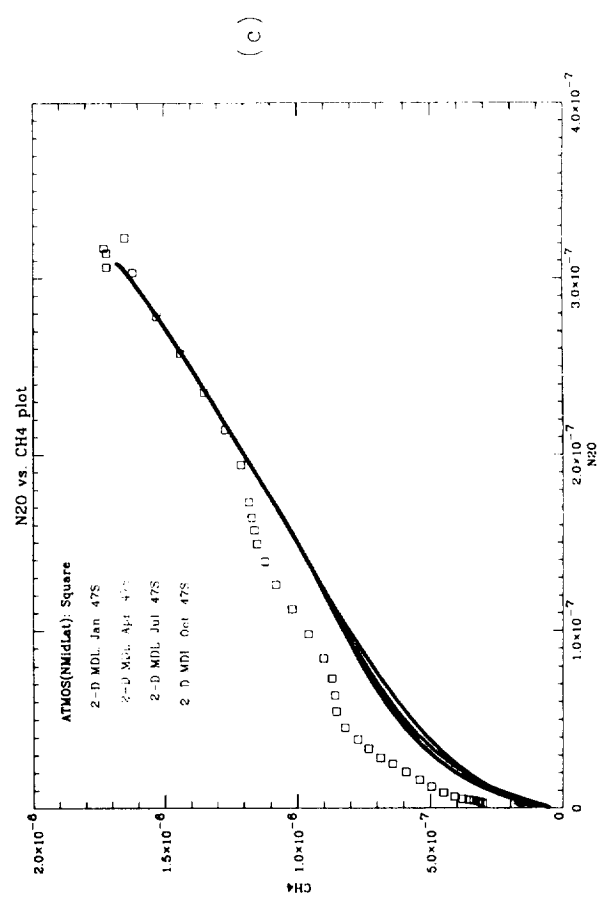
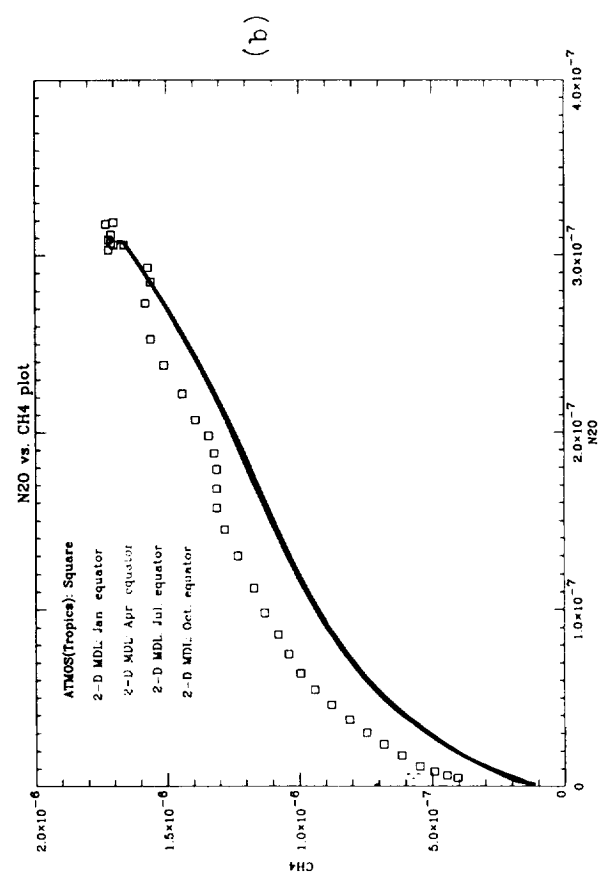
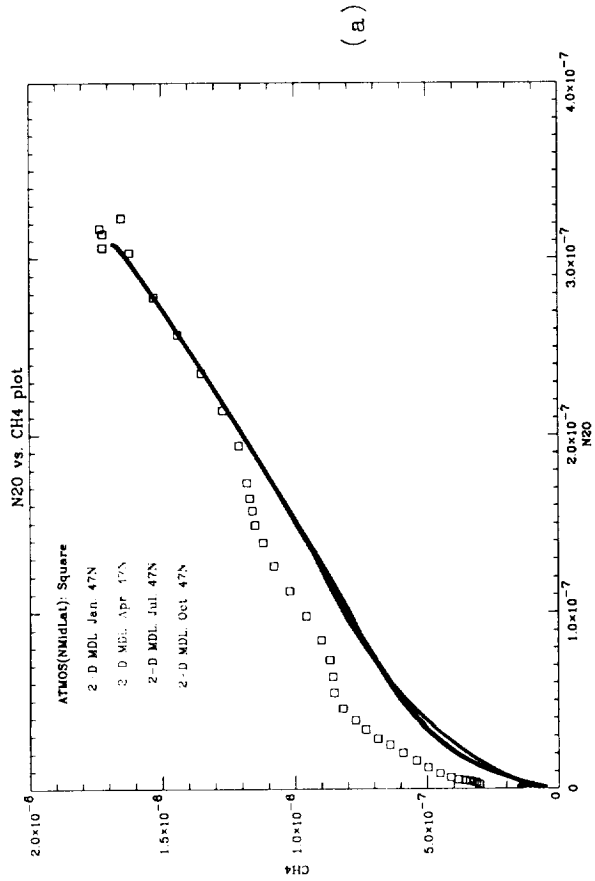
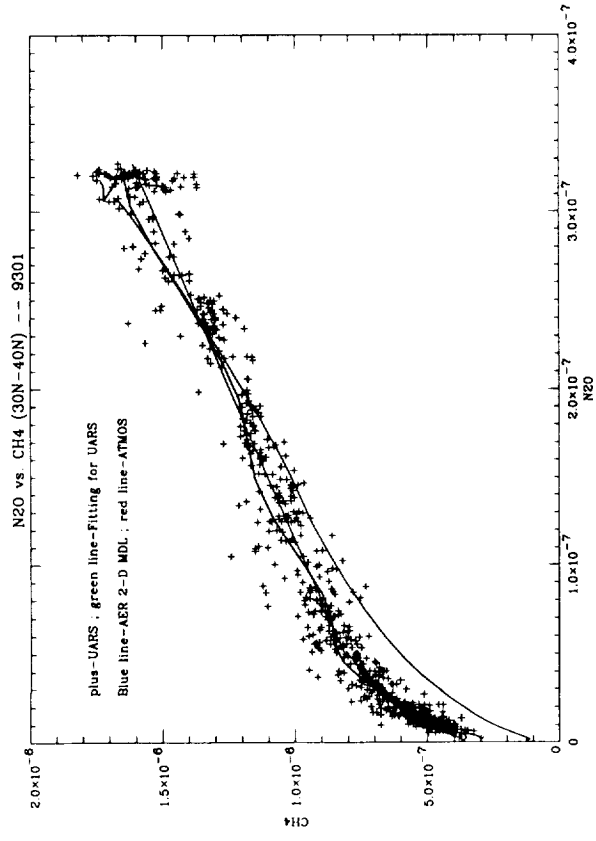
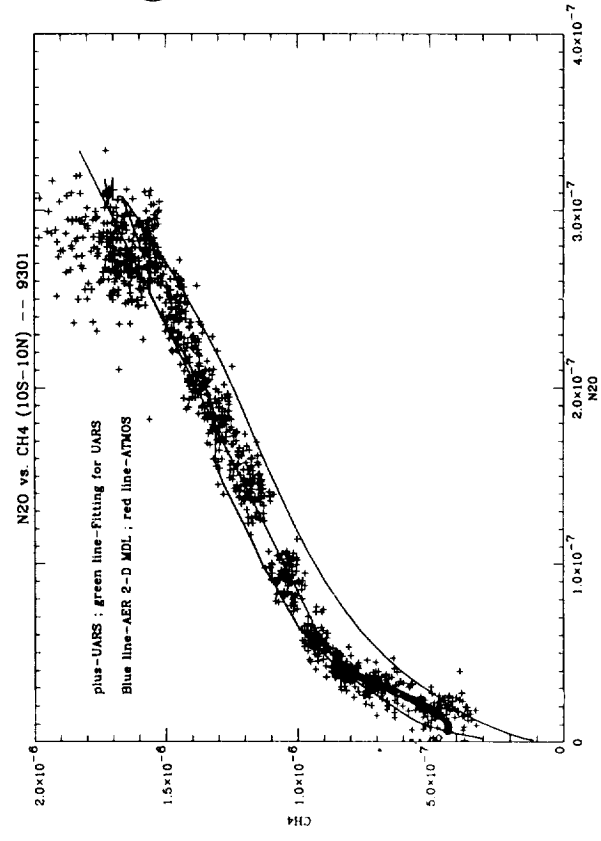


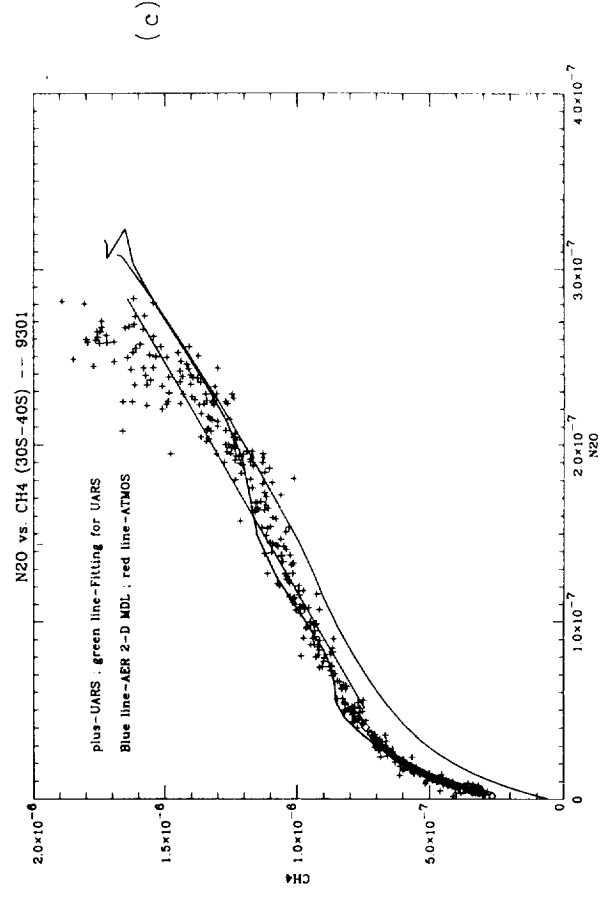
Figure 2



(a)



(b)



(c)

Figure 3

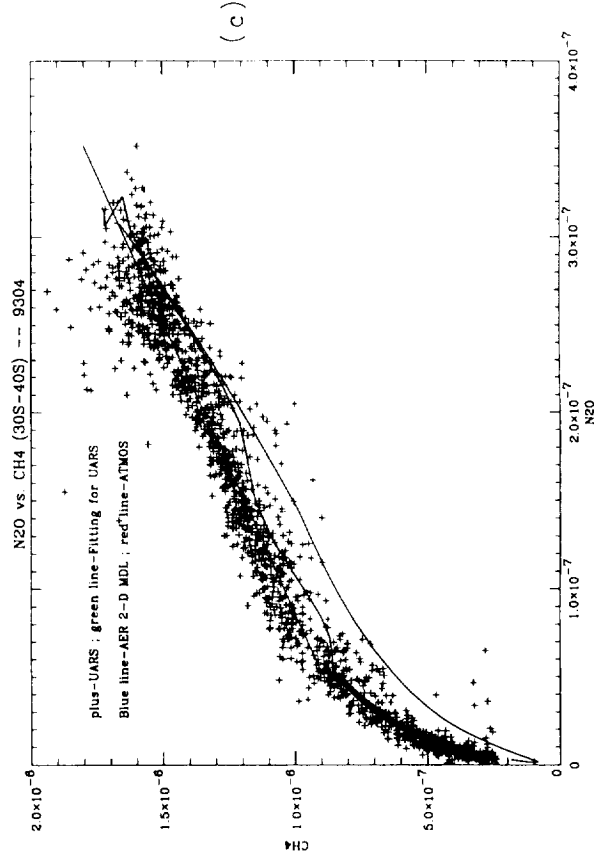
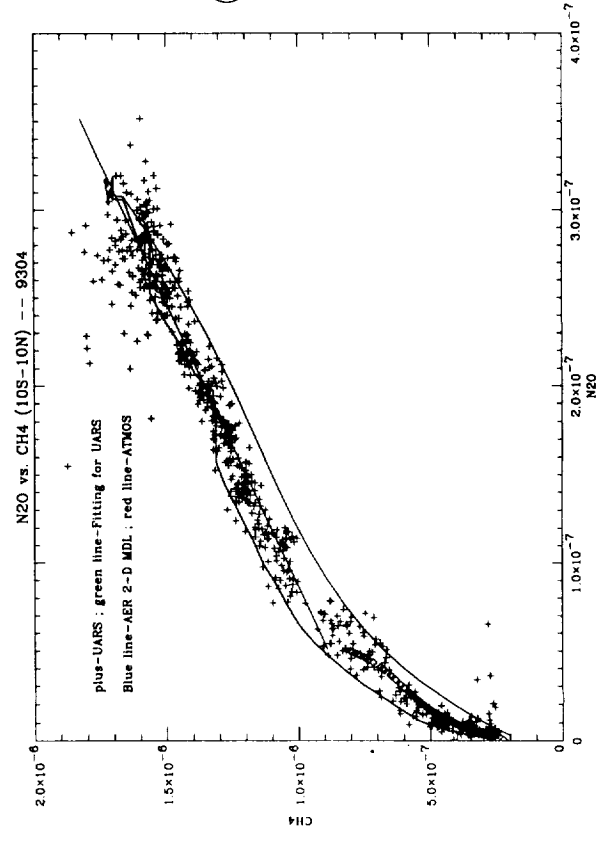
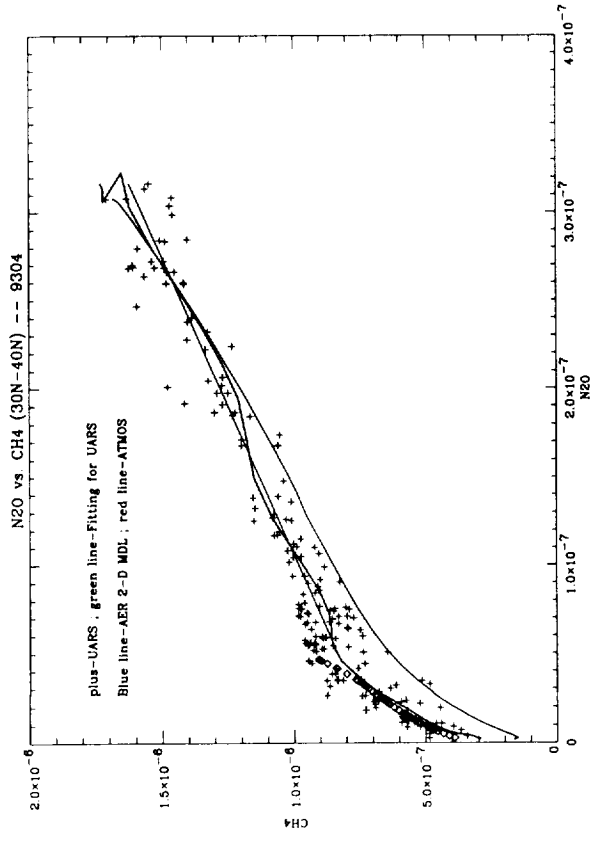


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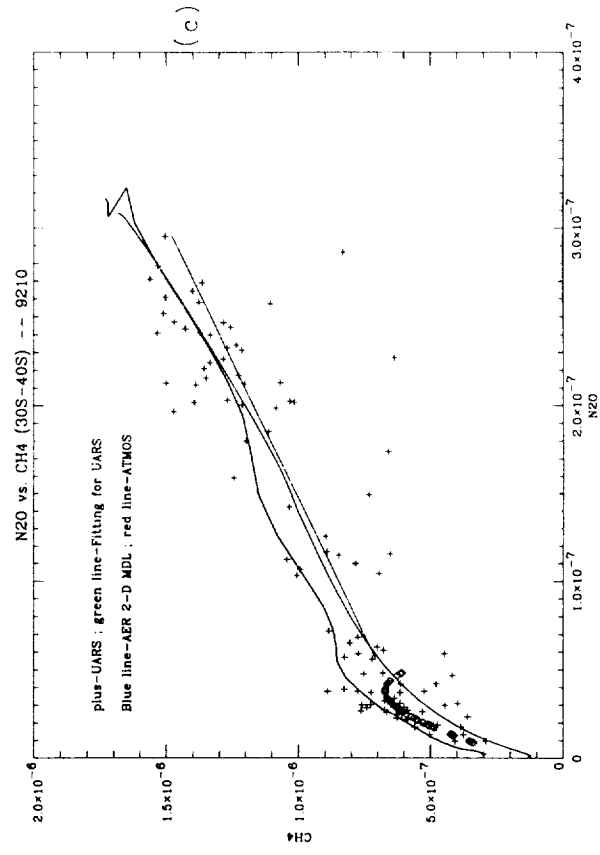
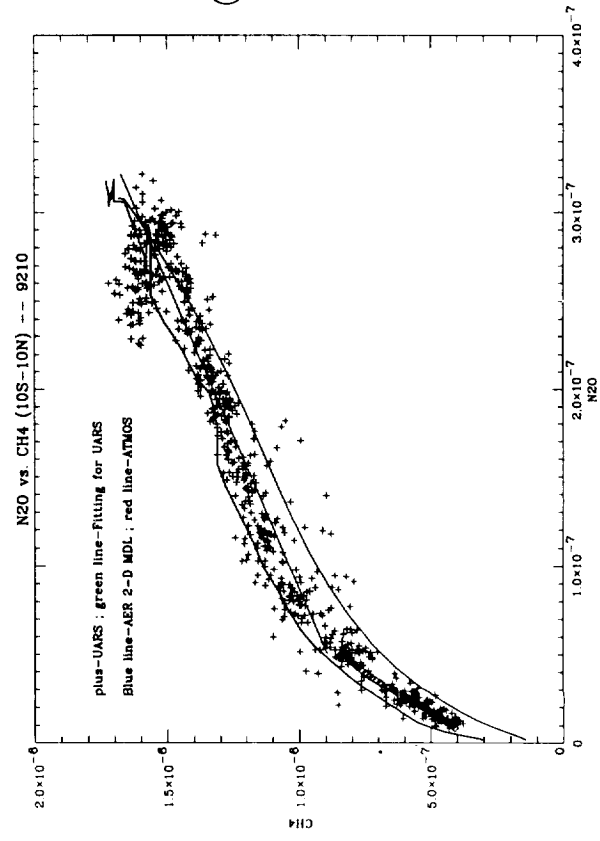
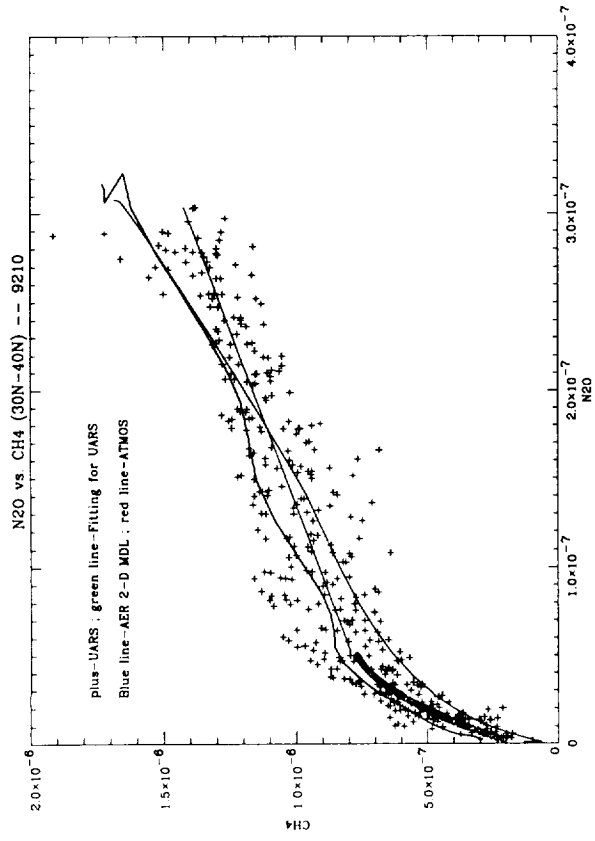
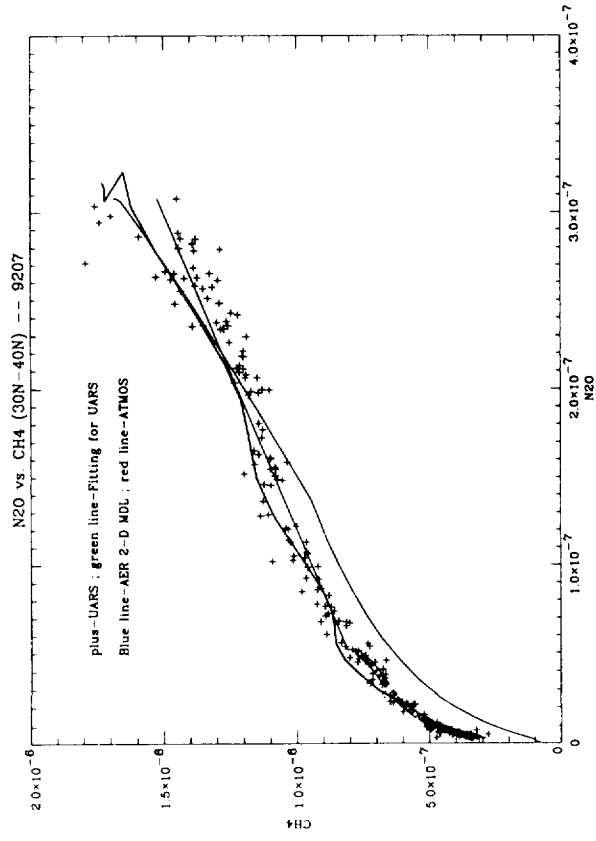
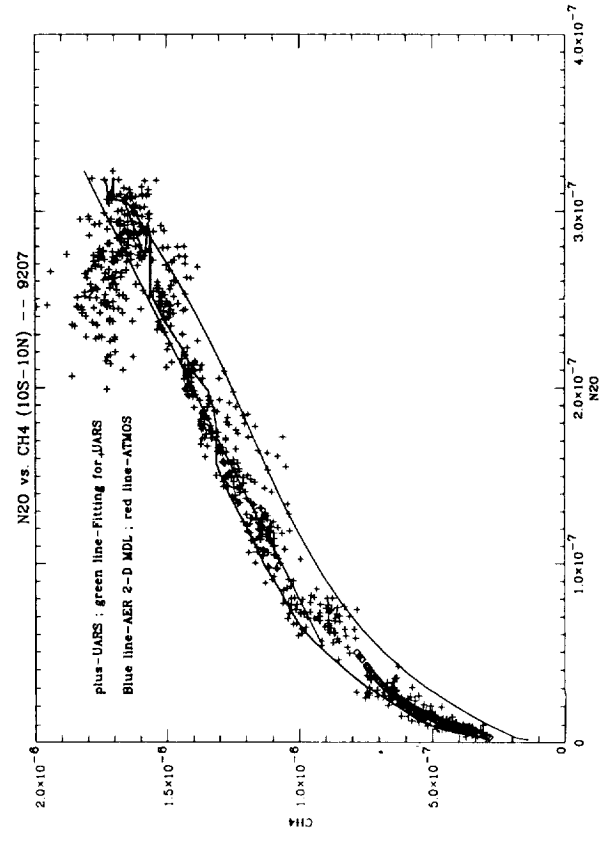


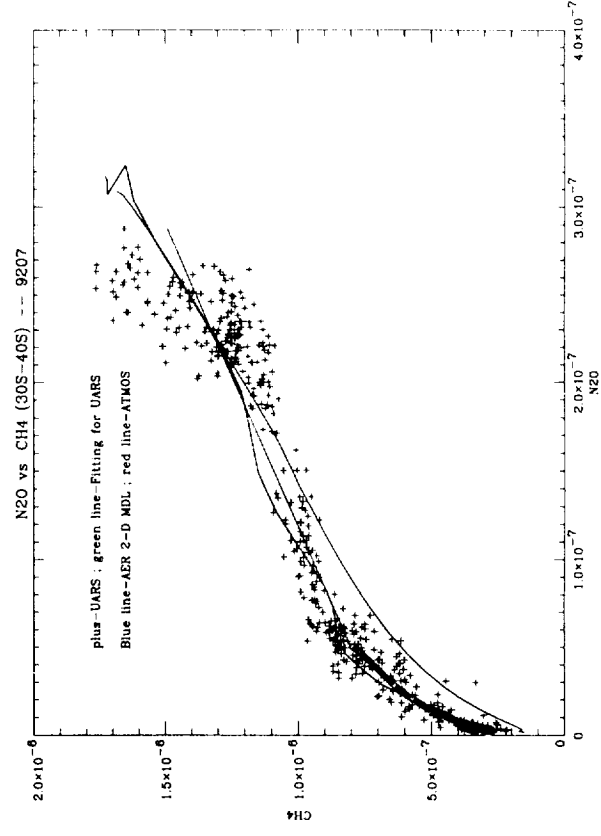
Figure 5



(a)



(b)



(c)

Figure 6

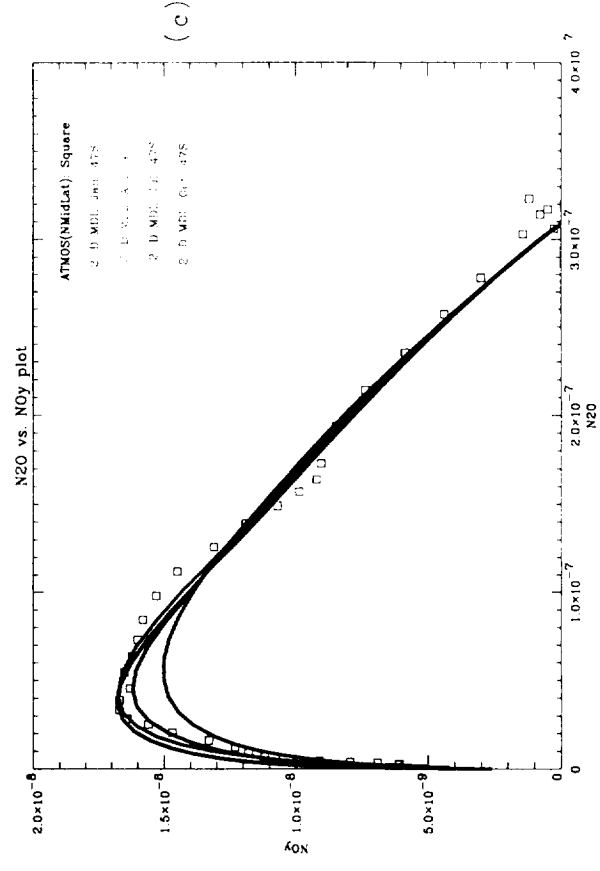
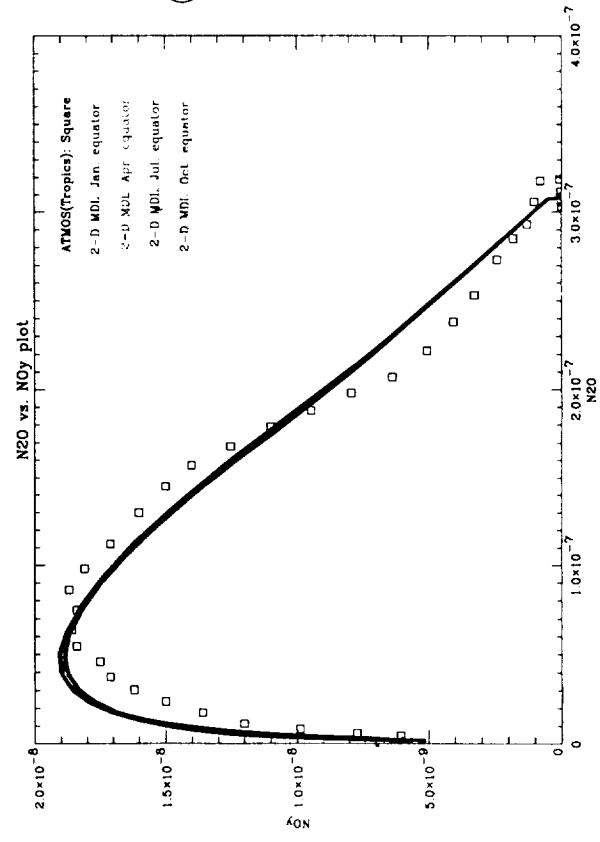
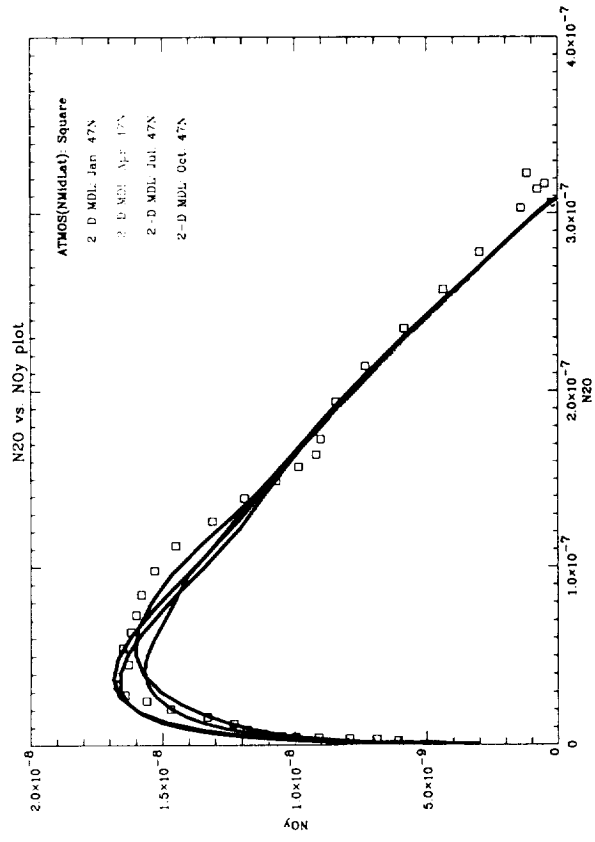


Figure 7

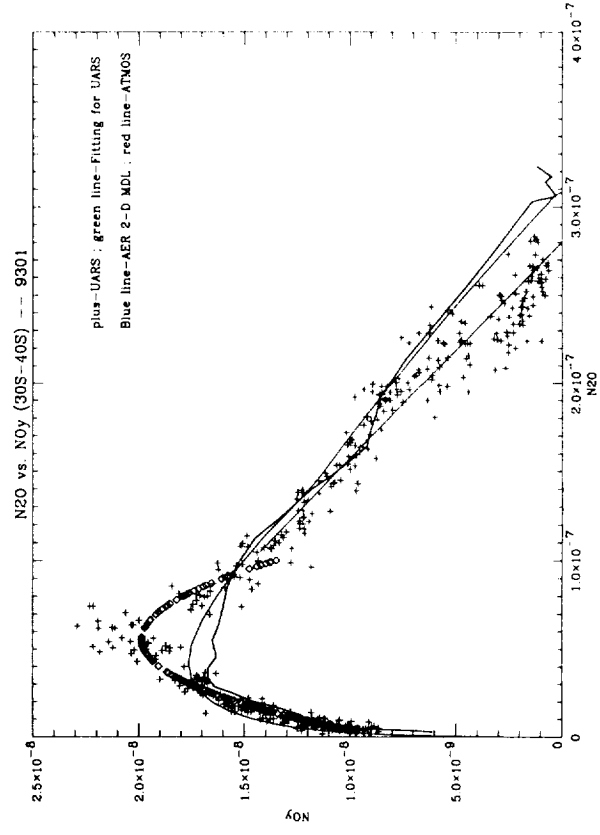
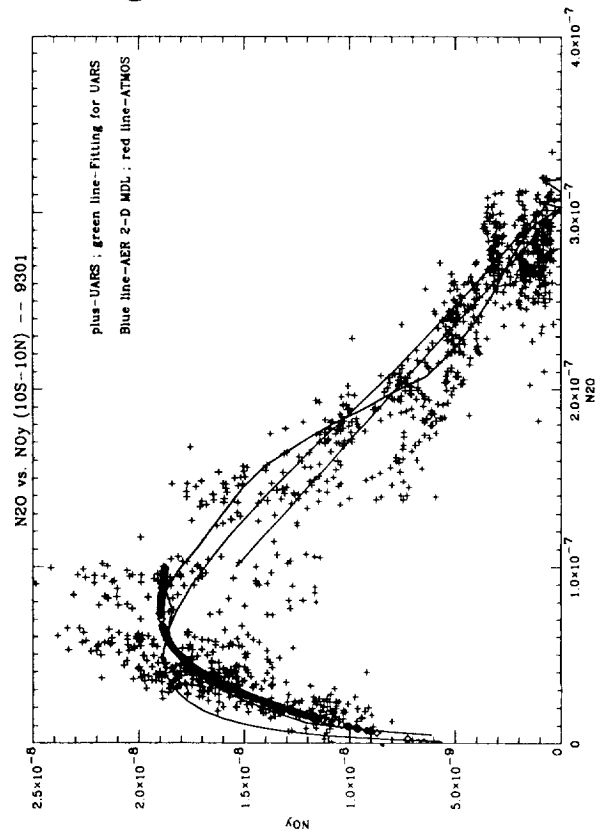
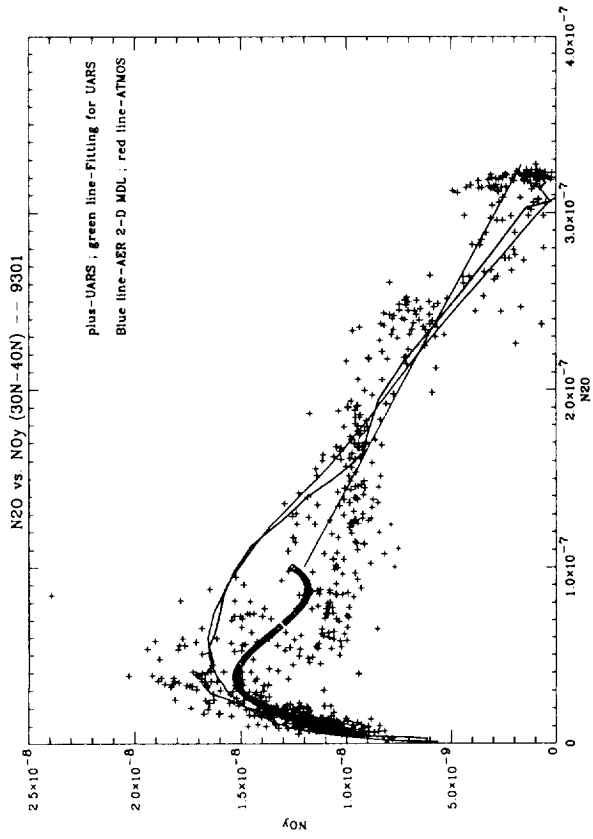
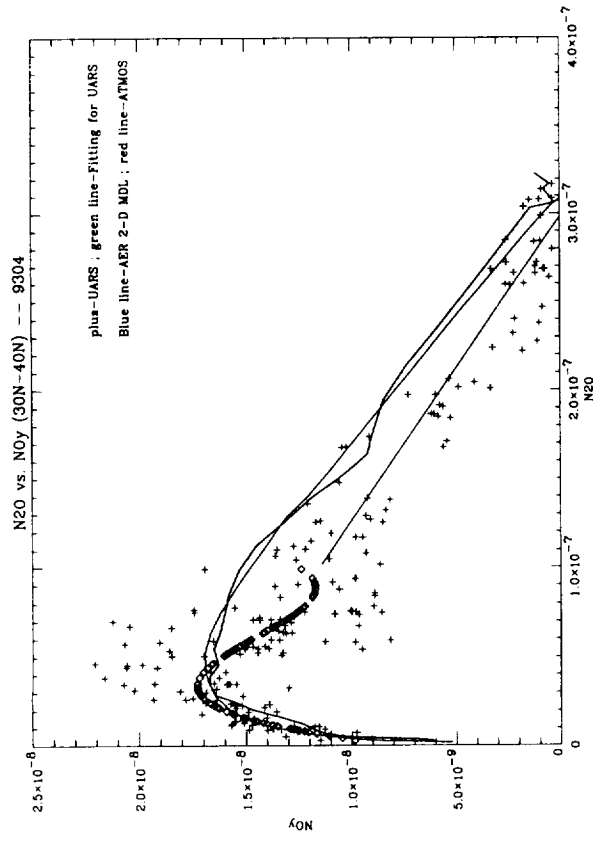
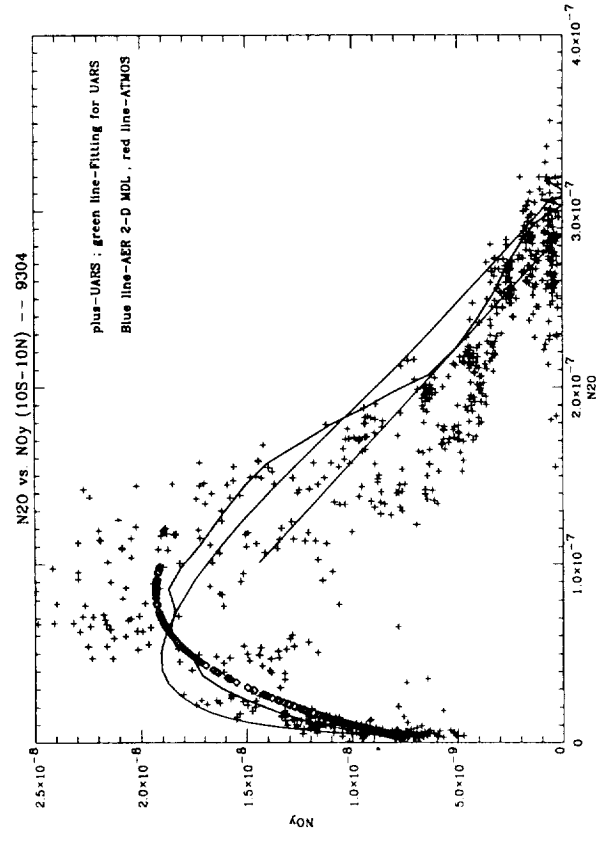


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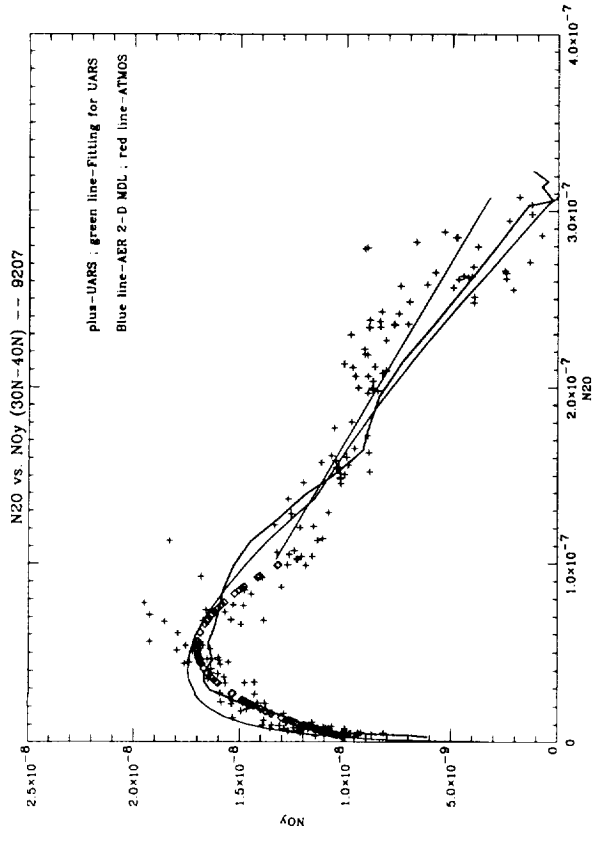


(a)

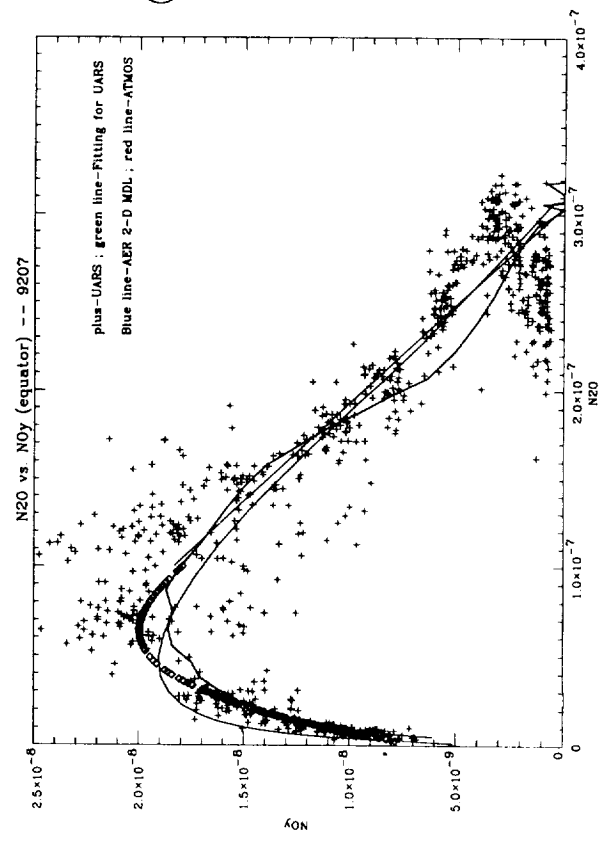


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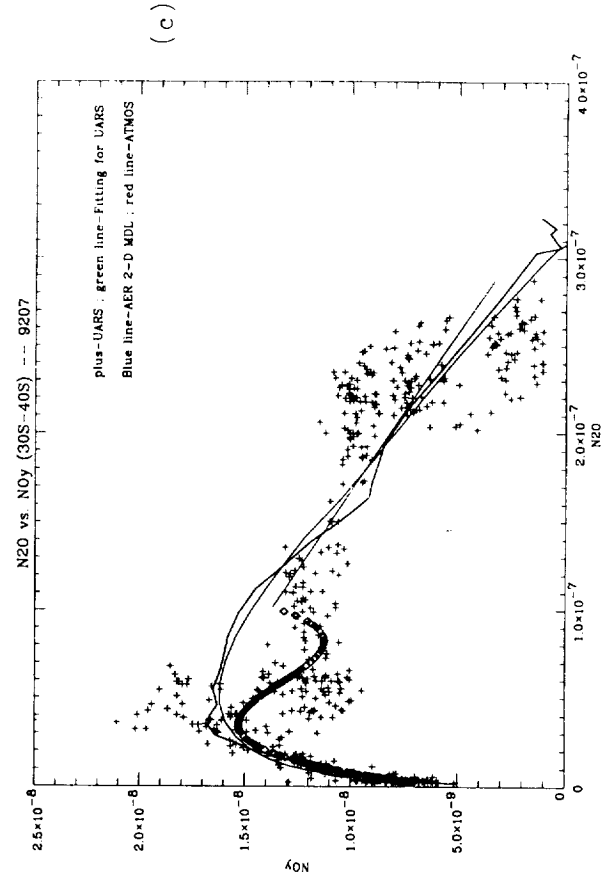
Figure 9



(a)



(b)



(c)

Figure 10

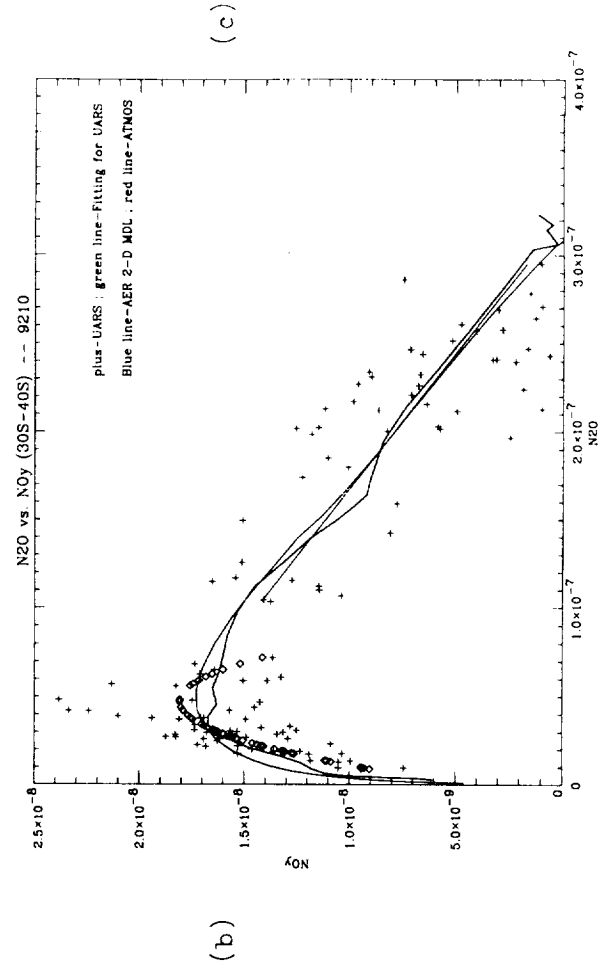
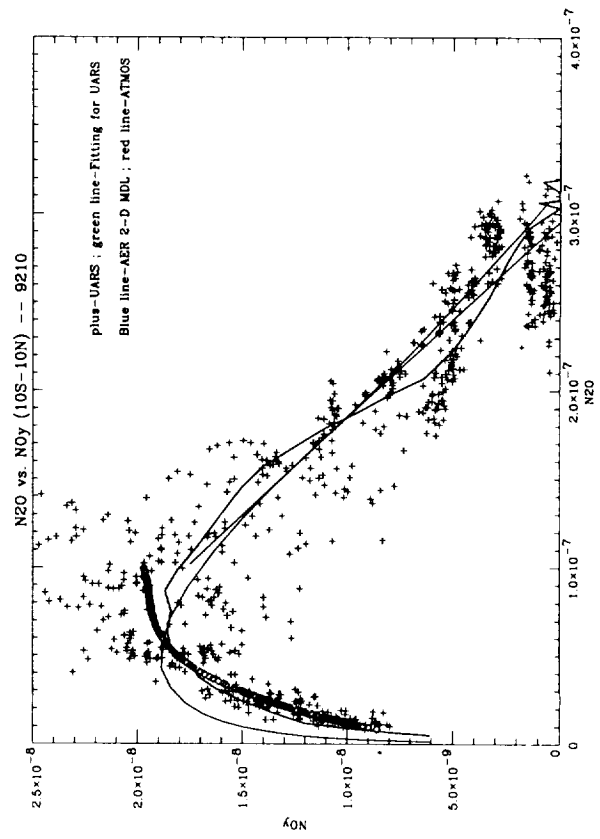
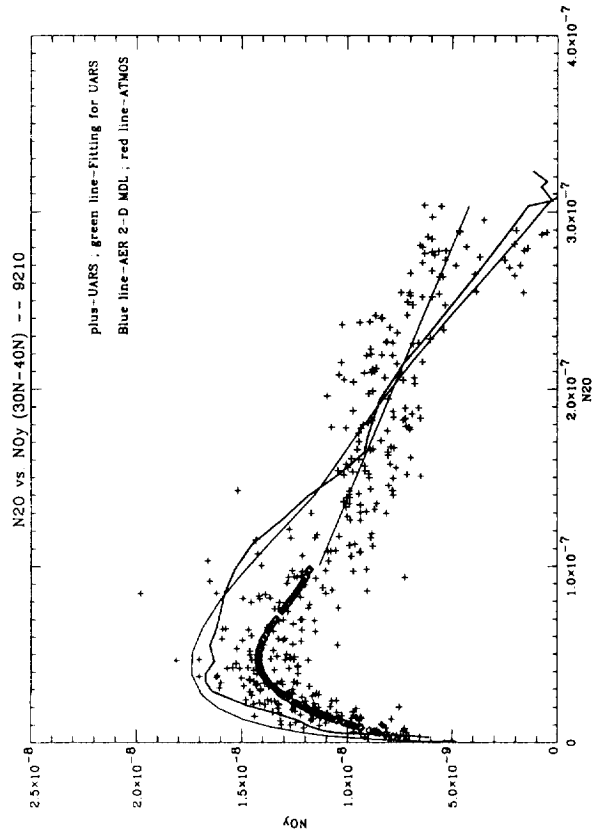


Figure 11

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